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METHOD OF LAMINATING GLASS SHEETS AND LAMINATED GLASS ARTICLE

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(56) Prior Art Documents
US 4732725
EP 200394
GB 2032844

(57) Claim

1. A method of laminating glass sheets, the method comprising the steps of:

(a) providing a glass sheet assembly comprising a pair of opposed glass sheets which are spaced from each other and spacer means located between the glass sheets, the spacer means being air permeable and liquid impermeable and extending along peripheral edges of the glass sheets, the glass sheet assembly being in a substantially horizontal orientation;

(b) introducing a measured volume of a liquid laminating resin between the glass sheets so that the resin contacts the inner surfaces of both the top and bottom glass sheets as it is introduced into the space between the sheets, the introduction of resin being controlled so that a resin meniscus between the top and bottom sheets spreads outwardly in a controlled manner;

(c) filling the space between the glass sheets with the measured volume of resin, air which is displaced by the resin being evacuated through the spacer means; and

(d) permitting the resin to cure and solidify thereby to form an interlayer between the glass sheets.

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ORIGINAL

COMPLETE SPECIFICATION

STANDARD PATENT

Invention Title:

METHOD OF LAMINATING GLASS SHEETS AND LAMINATED GLASS ARTICLE.

The following statement is a full description of this invention, including the best method of performing it known to me:-

glass sheet assembly and air is evacuated at an opening in the seal remote from the inlet opening.

GB-B-2032844 discloses a method of producing a laminate in which a glass sheet assembly is held in a substantially vertical orientation and liquid resin is poured into the interlayer space between two glass sheets which are spaced by spacer of gas permeable tape.

EP-B-0200394 discloses a method of producing laminated sheet material in which a liquid resin is poured into a concavity in a central zone of a first glass sheet and then a second glass sheets is located over the first glass sheet. A liquid impermeable and air permeable sealant is applied between the sheets around the periphery thereof and the first and second sheets are caused to assume a planar position and then pressure is applied on the sheets for the liquid resin and the air to flow outwardly in the interspace between the sheets.

The present invention aims to overome or alleviate the problems inherent in the prior art described above.

According to a first broad aspect of the present invention there is provided a method of laminating glass sheets, the method comprising the steps of: (a) providing a glass sheet assembly comprising a pair of opposed glass sheets which are spaced from each other and spacer means located between the glass sheets, the spacer means being air permeable and liquid impermeable and extending along peripheral edges of the glass sheets, the glass sheet assembly being in a substantially horizontal orientation; (b) introducing a measured volume of a liquid laminating resin between the glass sheets so that the resin contacts the inner surfaces of both the top and bottom glass sheets as it is introduced into the space between the sheets, the introduction of resin being controlled so that a resin meniscus between the top and bottom sheets spreads outwardly in a controlled manner;

glass sheets and the other side of the tape is covered by a removable covering element. The region may extend along the whole of one side of the glass sheet assembly.

Still more preferably, after the introducing step (b) the covering element is removed from the tape and the glass sheets are additionally adhered together at the said region by the tape.

A method ay further comprise pressing the two glass sheets together during step (c) so as to assist filling of the space between the glass sheets by the resin and evacuation of air through the spacer means. The pressing may be performed in a low pressure environment which enhances evacuation of air through the spacer means.

During the introducing step (b) the glass sheet assembly may be inclined at a small angle with respect to the horizontal. A typical angle is around 5^{o} to the horizontal.

Preferably, the liquid laminating resin has a viscosity of from 50 to 4000 centipoise (at a temperature of $25^{o}C$). This range is appropriate when the resin is introduced into the glass sheet assembly which is horizontal or inclined to the horizontal. More preferably, the viscosity is from 300 to 4000 centipoise (at a temperature of 25 ^{o}C). This range is appropriate when the glass sheet assembly is inclined to the horizontal during introduction of the resin. Especially preferred laminating resins have a viscosity (at a temperature of $25^{o}C$) of around 300 centipoise or around 2000 centipoise. In this specification, all liquid viscosity values are specified at a temperature of $25^{o}C$.

There is also provided a laminated glass article formed by the methods of either the first or second aspects of the invention. The method of the invention may include, prior to charging of a laminating resin into a central region between the two glass sheets, effective washing or cleaning of at least the opposing surfaces of the glass sheets. Cleaning may take place by any conventional method utilising known cleaning liquids.

Still further, the method may include applying the air permeable/liquid impermeable double sided adhesive tape to one of the two glass sheets along the peripheral edges thereof, intially retaining a removable covering element on the exposed side of the adhesive tape.

As such, the method of the invention may include removing the said covering element from the adhesive tape prior to charging the laminating resin into the space between the two glass sheets. A portion of the said covering element may be retained in place during charging of the laminating resin, this region being the region across which a charging nozzle can pass into the central region between the glass sheets, thus ensuring that the resin will not come into contact with the exposed surface of the adhesive tape upon retraction of the charging nozzle and before pressing the two sheets together.

Handling of the glass sheets during the laminating operation may be conventional, glass sheets being held in a substantially vertical configuration on a suitable rack before and between the method steps, while a tilt table is used for holding either one or both glass sheets in a suitable horizontal configuration during method steps such as while applying the adhesive tape during charging of the laminating resin into a space between the glass sheets and during subsequent pressing and storage.

The method of the invention particularly may include holding the operative top glass sheet in its spaced

Embodiments of the present invention will now be described by way of example only, with reference to the accompanying drawings, in which:-

FIG. 1 is a perspective view of a glass sheet carrying a sealing means for forming a laminated glass article in accordance with a first embodiment of the present invention;

FIG. 2 is a perspective view of a glass sheet assembly incorporating the glass sheet and sealing means of Fig. 1 for manufacture of a laminated glass article in accordance with a first embodiment of the present invention during introduction of a liquid laminating resin between the glass sheets;

FIG. 3 is an enlarged part-sectional side view of a central part of the assembly of Fig. 2 and shows in greater detail the glass sheet assembly of Fig. 2 during introduction of the liquid laminating resin between the glass sheets;

FIG. 4 is a perspective view of the glass assembly of Fig. 2 after a measured volume of the liquid laminating resin has been introduced between the glass sheets and after sealing of the entire peripheral edge of the glass sheet assembly;

FIG. 5 is a perspective view of a laminated glass article in accordance with the invention having been formed from the glass assembly of Fig. 4 by filling of the interlayer space between the glass sheets by the resin; and

FIGS. 6(a) to (h) show schematically a series of sequential step in a method of laminating glass sheets in accordance with the second embodiment of the present invention.

Referring to Figure 1, a sheet 2 of glass, which may be toughened or annealed glass, and which in the preferred embodiment is shown as being rectangular, has adhered around the peripheral edge 4 thereof a self-adhesive foam tape 6

foam tape 6 defines the edge thickness of the interlayer space 24 and thus the thickness of the edge of the interlayer in the resultant laminated article. The thickness of the body of the interlayer in the resultant laminated article can, particularly for large area laminates, vary slightly from that of the foam tape depending upon the volume of resin introduced into the interlayer space 24. Typically, for a large area (e.g 3.6 sq. metres) laminate the foam tape may be 1.6mm thick and the interlayer may be 1.8 mm thick, i.e. the interlayer may be slightly thicker than the laminate. Typically, the interlayer space 24 is from 0.5 to 2mm thick. Particularly preferred thicknesses of the interlayer space are 0.8mm, 1.0mm, 1.3mm, 1.5mm, 1.6mm and 1.8mm. As is shown in Figure 2, an injection nozzle 26, typically of flexible plastics material, and being surrounded by a protective sleeve 28 of plastics material, which latter prevents liquid resin which is injected from the injection nozzle as described hereinafter inadvertently being deposited on the glass sheets by the injection nozzle 26 when the nozzle is introduced into or removed from the glass sheet assembly, is slid into a gap 30 formed between the tape 6 and the second glass sheet 18 by a separating device 32 which is disposed between the two glass sheets 2,18. The separating device 32 bends slightly upwardly the top glass sheet 18 thereby to form the gap 30 which is located above the region 14 of the tape 6 which is covered by the removable covering element 16. The end 34 of the nozzle 26 is disposed at a substantially central region of the interlayer space 24 between the two glass sheets 2,18. The protective sleeve 28 is prevented from inadvertently adhering to the adhesive surface 8 of the tape 6 by the removable covering element 16. The entire assembly is disposed on a horizontal support surface 36 and, by means of a raising device 38, the glass sheet assembly 20 is inclined at a small angle to the horizontal, typically 5^{o}, in a downwardly direction with respect to flow of liquid resin from the end 34 of the nozzle 26. Thus, the raising device 38 is preferably located beneath the glass sheet assembly 20 at a position substantially underneath that edge 40 of the glass sheet assembly 20 through which the injection nozzle 26 is inserted.

from the interlayer space 24 through the air permeable tape 6. The filling process can be carried out by simply permitting the gravitational weight of the upper sheet 18 acting on the body of liquid resin 42 to spread the liquid resin 42 uniformly throughout the interlayer space 24 so as completely to fill the interlayer space 24. This is generally applicable if the laminate has a relatively small surface area and if the viscosity of the resin is not particularly high. Alternatively, the glass sheet assembly can be disposed in a reduced pressure environment, such as in a vacuum box, thereby to press the two sheets 18,2 together and assist evacuation of air from the interlayer space through the air permeable tape 6. This is generally applicable for higher viscosity resins. If desired, pressure may additionally be applied directly to the upper glass sheet 18 to enhance the pressing of the two glass sheets 2,18 together.

After the interlayer space 24 has been completely filled with liquid resin 42. the resin 42 is permitted to cure and solidify thereby to form the resultant glass laminate 52 which is shown in Figure 5, the laminate 52 having an interlayer 54 formed from the resin 42 which adheres the two glass sheets 2,18 together and also having the tape 6 around the periphery thereof.

Typically, the laminating process is carried out at a temperature of around 15 to 25^{o}C.

In the illustrated embodiment, the filling of the interlayer space 24 by the resin 42 is carried out with the glass assembly 20 inclined at a small angle to the horizontal. Depending on the viscosity of the resin, and on the dimensions of the interlayer space, the angle can be varied as required. It has been found that the angle can vary up to 20^{o} but typically is around 5^{o}. It has been found that this assists the filling of the interlayer space 24 by the liquid resin 42 since the resin tends to flow down the inclined glass surface controllably. However, the liquid resin may be introduced between the glass sheets with the glass sheet being in a horizontal orientation. Thus in

It has been found in practice that a number of parameters affect the formation of the resin meniscus in accordance with the method of the invention for any particular application of the invention. Thus, the liquid resin viscosity, thickness of the interlayer space, inclination of the glass sheet assembly, size of laminate to be produced, temperatures of fabrication, location of the introduction of the liquid resin intc the interlayer space, surface tension between the liquid resin and the glass surfaces and the use of a vacuum or additional pressure to assist even distribution of the resin in the interlayer space are all interrelating parameters which can affect the formation of the meniscus and controlled introduction of the liquid resin into the interlayer space. The man skilled in the art can readily select the appropriate parameters for any given laminate to be produced in accordance with the invention by routine testing. As a general rule, the higher the resin viscosity the greater the use of an inclined glass sheet assembly during resin introduction and the greater the use of a vacuum source to evacuate air from the interlayer space. Also, larger glass sheet areas and/or thinner interlayer spaces are generally easier to fill with lower viscosity liquid resins.

The prior art relating to cast-in-place laminated layers has generally attempted to address the problem of avoiding the formation of such bubbles. This embodiment ~~The present invention,~~ by controlled formation of a meniscus extending between the two glass sheets, thereby controls the initial disposition of the resin liquid between the glass sheets which subsequently prevents such bubble formation. This a real technical advance in the art, particularly when high viscosity resins are employed.

The present invention has, especially when employing the preferred high viscosity resin materials for the interlayer, particular application in the manufacture of safety laminates, security and bullet resistant laminates, acoustic laminates,

When in this configuration, as shown in Figure 6(d), the top glass sheet 60b is engaged by a plurality of suction cups 74 of a lifting gantry, the suction cups 74 typically being disposed at approximately 300mm centres permitting the sheet 60b to be picked up from the bottom sheet 60a and be held in a horizontal configuration as shown. When so picked up the covering elements of the strips 66 along three sides of the sheet 60a can be removed while the covering element of the strip 66a is maintainted on the said strip.

Thereafter, as shown in Figure 6(e), the lifting gantry can lower the top glass sheet 60b to a position in which it is spaced from the sheet 60a by approximately 4mm, whereafter a charging nozzle 76 is inserted into the space between the sheets 60, to a location where the nozzle end 78 is approximatley centrally located with respect to the sheets 60. The cross sectional profile and size of the nozzle 76 is such that it can fit between the sheets.

When properly located, a laminating resin, in the form of a polysester resin of suitable viscosity, can be charged into the space between the sheets 60, the spacing between the sheets 60 and the viscosity of the resin being such that the resin comes into contact with both the opposing surfaces of the sheets 60, thus forming a continuous resin body 80 between the sheets 60, this body 80 spreading in a controlled manner until a predetermined required volume of resin has been charged into the said space.

Thereafter, the nozzle 76 can be retracted from between the sheets 60, whereafter the covering element of the adhesive strip 66a can be removed. This covering element is initially kept in position to ensure that resin attaching to the nozzle 76 will not come into contact with the adhesive surface of the strip 66a, which can affect sealing between the sheets 10 when adhered together.

It must be understood that the exact steps of the method as described above can be varied in various different respects, while still including the main principle of the invention, which relates to the charging of a laminating resin between two sheets in the manner described above. Insofar as this particular step is concerned, the spacing between the sheets and the viscosity of the resin is variable, the main requirement being that the resin will immediately make contact with and attach itself to both sheets when charged into the space between the sheets.

It is believed that the complete method as described can become fully mechanised. Another benefit of the method being that possible ingress of dirt particles between sheets is greatly eliminated because sheets remain in a relatively closely spaced configuration above one another, particularly when the resin is introduced. Also by utilising the method as proposed, the possible formation of air bubbles between sheets also is greatly eliminated, but ensuring an efficient process with a very low reject rate.

Clearly the method of the invention also can be used for laminating various other materials having similar properties to that of glass and, therefore, requiring a similar type laminating process. Also, the method the invention can be utilised for laminating three or more sheets of material.

The present invention relates particularly to the laminating of sheets of glass, although the invention can also be employed for laminating sheets of any other materials, such as perspex, polyester, polycarbonate, polyacrylate, or other synthetic plastics, which are conventionally laminated in a similar manner to glass. For example, the present invention may be employed to manufacture bullet resistant glazing comprising a laminate of glass/interlayer (formed from cast-in-place resin)/polycarbonate. In this specification, any reference to laminating of glass sheets should be interpreted as a reference to laminating sheets of other materials as identified hereinabove.

5. A method according to claim 3 or claim 4 wherein a portion of the injection nozzle which extends between the glass sheets is at least partly covered by a protective member which substantially presents the injection nozzle from contacting the surface of the glass sheets.

6. A method according to claim 5 wherein the protective member comprises a plastics sleeve which surrounds the injection nozzle.

7. A method according to any foregoing claim wherein the spacer means comprises a foam tape having an open-cell structure which is self-adhesive on both sides thereof.

8. A method according to claim 7 wherein during introducing step (b) the tape is adhered to both the top and bottom glass sheets thereby to adhere the glass sheets together around substantially their entire peripheral edges except at least at a region thereof where the resin is introduced between the glass sheets, at which region one side of the tape is adhered to the glass sheets and the other side of the tape is covered by a removable covering element.

9. A method according to claim 8, wherein after introducing step (b), the covering element is removed from the tape and the glass sheets are additionally adhered together at the said region by the tape.

10. A method according to any foregoing claim further comprising pressing the two glass sheets together during step (c) so as to assist filling of the space between the glass sheets by the resin and evacuation of air through the spacer means.

11. A method according to claim 10 wherein the pressing is performed in a low pressure environment which enhances evacuation of air through the spacer means.

retaining the laminated sheets in a flat horizontal configuration until the resin has effectively set and cured.

18. A laminated glass article whenever formed by the method of any one of claims 1 to 17.

19. A laminated glass article substantially as hereinbefore described with reference to Figures 1 to 5 or Figure 6.

DATED THIS 07TH DAY OF MARCH 1994

PILKINGTON GLASS LIMITED

By its Patent Attorneys:
GRIFFITH HACK & CO.

Fellows Institute of Patent
Attorneys of Australia

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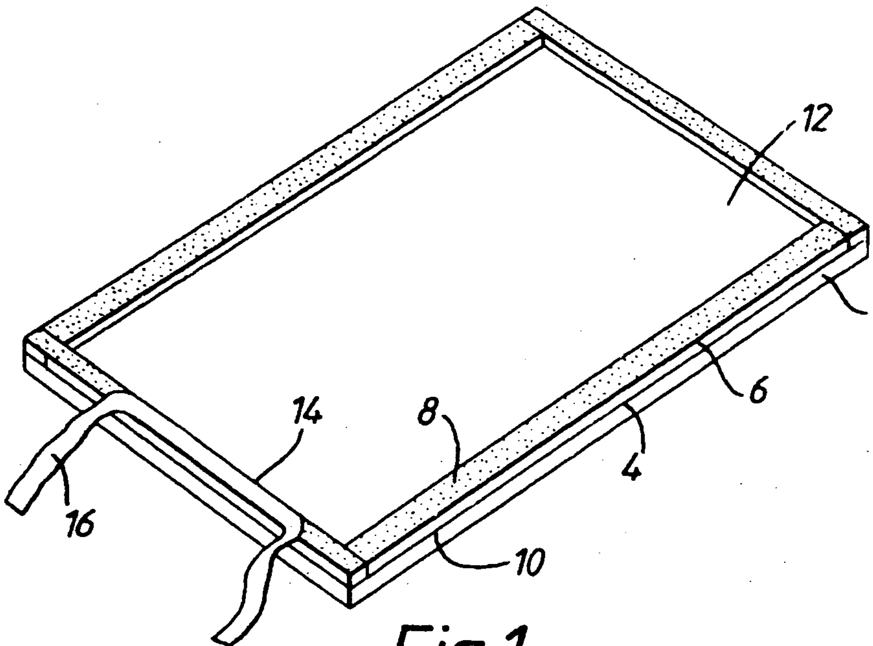

Fig.1.

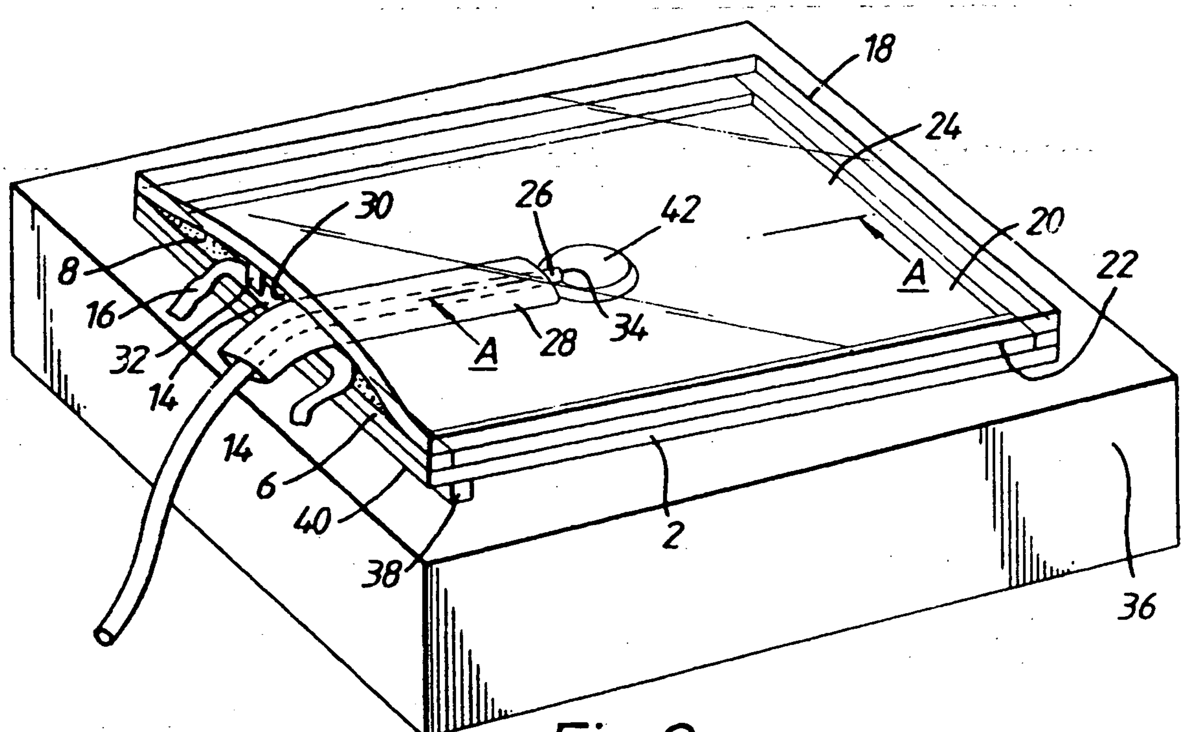

Fig.2.

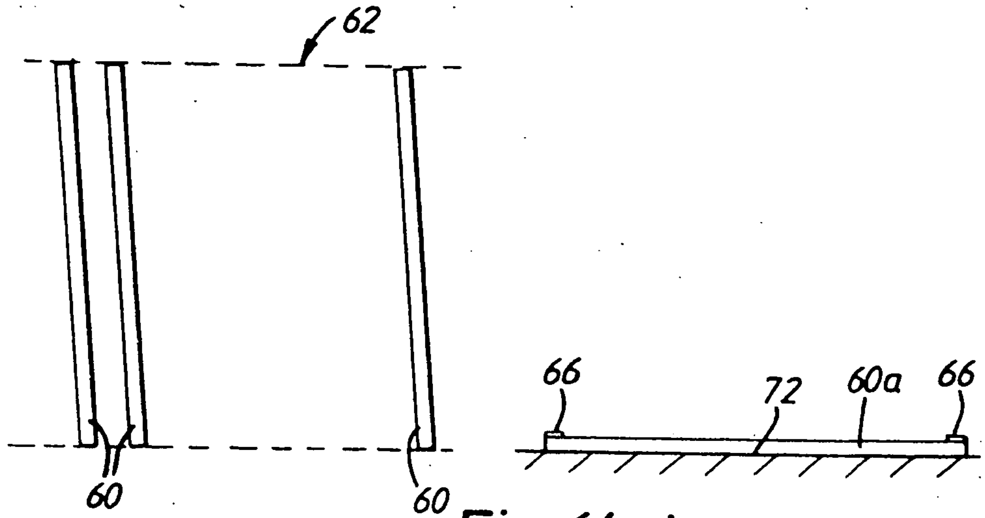

Fig.6(a).

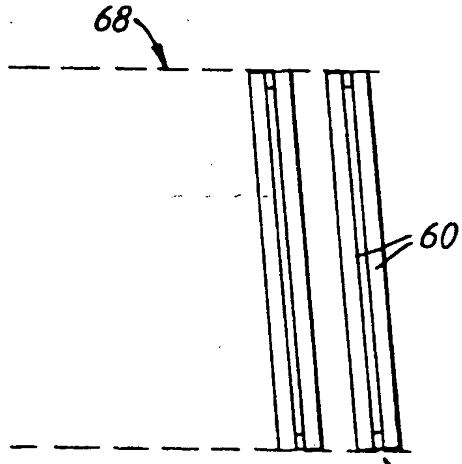

Fig.6(b).

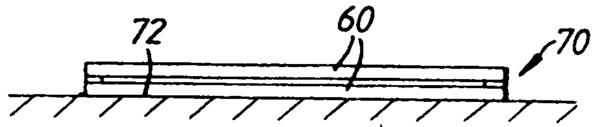

Fig.6(c).